US

CLAIMS

1. A ceramic support which comprises a crystal lattice having at least one of oxygen vacancy and lattice defects therein, by which said ceramic support can support a catalyst component.

2. The ceramic support according to claim 1, wherein said ceramic support has a shape of at least one of a honeycomb, a pellet and a powder.

3. A ceramic support which has cracks by which said ceramic support can support a catalyst component.

4. The ceramic support according to claim 4, wherein said cracks are present in at least one of the crystal and the amorphous phases.

5. The ceramic support according to claim 3, wherein said cracks have a width in a range of 100 nm or less.

6. The ceramic support according to claim 3, wherein said ceramic support has a shape of at least one of a honeycomb, a pellet and a powder.

7. A ceramic support capable of supporting a catalyst, comprising a ceramic body having fine pores with a diameter or width of up to 1000 times the ion diameter of a catalyst component to be supported on the surface of said ceramic body, the number of said fine pores being not less than 1×10^{11} pores per liter.

8. The ceramic support according to claim 7, wherein said ceramic body has five pores with a diameter or width of 1 to 1000 times the ion diameter of a catalyst component to be supported on the surface of said ceramic body.

9. The ceramic support according to claim 7, wherein said number of said fine pores is not less than 1×10^{16} pores per liter.

10. The ceramic support according to claim 7, wherein said fine pores are composed of at least ones of oxygen vacancies and lattice defects in the crystal

lattice of said ceramic, fine cracks on the surface of said ceramic body, and vacancies of an element or elements constituting the ceramic.

11. The ceramic support according to claim 7, wherein said ceramic mainly comprises cordierite.

12. The ceramic support according to claim 7, wherein said ceramic support is in the form of a honeycomb.

13. The ceramic support according to claim 7, wherein said ceramic support has a compressive strength in the direction of the flow channel of not less than 1 MPa and a thermal expansion coefficient in the direction of the flow channel of not higher than $1.0 \times 10^{-6}/°C$.

14. The ceramic support according to claim 13, wherein said ceramic support has a compressive strength in the direction of the flow channel of not less than 10 MPa.

15. The ceramic support according to claim 7, wherein said ceramic support has the fine pores in a number of not less than 1×10^{17} pores per liter.

16. The ceramic support according to claim 7, wherein said diameter or width of said fine pores is in a range of 0.1 to 100 nm.

17. The ceramic support according to claim 7, wherein said fine pores have a depth of not smaller than a half of the ion diameter of a catalyst component to be supported on the surface of said ceramic body.

18. The ceramic support according to claim 11, wherein said ceramic has a content of oxygen in an amount of less than 47% by weight or more than 48% by weight.

19. The ceramic support according to claim 11, wherein said ceramic comprises cordierite crystals and the lattice constant of b_0 axis of the cordierite crystals is larger than 16.99 or smaller than 16.99.

20. The ceramic support according to claim 11,

wherein said ceramic includes cordierite crystals having one or more of at least one of oxygen vacancy and lattice defect in the unit lattice of cordierite crystal in an amount of not less than 4×10^{-8}% of said ceramic.

21. The ceramic support according to claim 20, wherein said ceramic includes said cordierite crystals having one or more of at least one of oxygen vacancy and lattice defect in the unit lattice of cordierite crystal in an amount of not less than 4×10^{-5}% of said ceramic.

22. The ceramic support according to claim 7, wherein said ceramic comprises cordierite crystals which comprise not less than 4×10^{-8} of at least one of oxygen vacancy and lattice defect per unit lattice of cordierite crystal.

23. The ceramic support according to claim 22, wherein said ceramic comprises cordierite crystals which comprise not less than 4×10^{-7} of at least one of oxygen vacancy and lattice defect per unit lattice of cordierite crystal.

24. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition and having oxygen vacancies in cordierite crystals, said honeycomb structure having a content of oxygen in an amount of less than 47% by weight.

25. The ceramic support according to claim 24, wherein said oxygen vacancies are formed by firing in a reduced pressure atmosphere, a reducing atmosphere, or a low oxygen concentration atmosphere.

26. The ceramic support according to claim 25, wherein said firing atmosphere is a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, a reducing atmosphere, or a low oxygen concentration atmosphere with a oxygen concentration in a range of not less than 0% and up to less than 3%.

27. The ceramic support according to claim 24,

wherein said oxygen vacancies are formed by replacing at least some of Si, Al and Mg elements constituting the cordierite by an element having a valency smaller than that of the replaced element.

28. The ceramic support according to claim 24, wherein said cordierite crystals have a lattice constant of b_0 axis of smaller than 16.99.

29. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition and having lattice defects in cordierite crystals, said honeycomb structure having a content of oxygen in an amount of more than 48% by weight.

30. The ceramic support according to claim 29, wherein said lattice defects are formed by replacing at least some of Si, Al and Mg elements constituting the cordierite by an element having a valency greater than that of the replaced element.

31. The ceramic support according to claim 29, wherein said cordierite crystals have a lattice constant of the b_0 axis of larger than 16.99 or smaller than 16.99.

32. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition and having a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof.

33. The ceramic support according to claim 32, wherein said ceramic support contains an alkali metal and an alkaline earth metal in a total amount of not less than 0.05% by weight.

34. The ceramic support according to claim 32, wherein said fine cracks have a width of not more than 100 nm and said fine cracks are formed by thermal shock or shock waves.

35. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure

mainly comprised of a cordierite composition and having at least ones of oxygen vacancies and lattice defects as well as having a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof.

36. The ceramic support according to claim 32 or 35, wherein said honeycomb structure includes said oxygen vacancies, lattice defects and fine cracks in a total number amount of at least 1×10^{16} per liter.

37. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition, said honeycomb structure having an oxygen content of less than 47% by weight or more than 48% by weight and a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof.

38. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition, a lattice constant of b_0 axis of the cordierite crystals of said honeycomb structure being larger than 16.99 or smaller than 16.99, said honeycomb structure having a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof.

39. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder and then

firing said honeycomb shape in a reduced pressure or reducing atmosphere to form a honeycomb structure mainly comprised of a cordierite composition.

40. The process according to claim 39, wherein said firing atmosphere is a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, or a reducing atmosphere.

41. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, at least some of said Si, Al and Mg sources being used from compounds which do not comprise oxygen,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder and then

firing said honeycomb shape in a low oxygen concentration atmosphere with a oxygen concentration in a range of not less than 0% to less than 3% to form a honeycomb structure mainly comprised of a cordierite composition.

42. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, some of said Si, Al and Mg sources being replaced by compounds comprising an element having a valency smaller than that of the replaced Si, Al or Mg,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder and then

firing said honeycomb shape in a reduced pressure atmosphere, a reducing atmosphere, an oxygen-containing atmosphere or an oxygen-free atmosphere to form a honeycomb structure mainly comprised of a cordierite composition.

43. The process according to claim 42, wherein said firing atmosphere is a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, a reducing atmosphere, an oxygen-containing atmosphere or an oxygen-free atmosphere.

44. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, some of said Si, Al and Mg sources being replaced by compounds comprising an element having a valency larger than that of the replaced Si, Al or Mg,

forming said cordierite materials into a honeycomb shape, and

firing said honeycomb shape in air to form a honeycomb structure mainly comprised of a cordierite composition.

45. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder,

forming said cordierite materials into a honeycomb shape,

firing said honeycomb shape to form a honeycomb structure mainly comprised of a cordierite composition, and

heating said honeycomb structure to a predetermined temperature followed by rapid cooling said honeycomb shape from said predetermined temperature.

46. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a

binder,

forming said cordierite materials into a honeycomb shape,

firing said honeycomb shape, and

rapidly cooling said fired honeycomb shape from a predetermined temperature during cooling from the temperature used in said firing to form a honeycomb structure mainly comprised of a cordierite composition.

47. The process according to claim 39, 41, 42, 44, 45 or 46, wherein said obtained fired honeycomb structure is further heated to a predetermined temperature and then rapidly cooled from said predetermined temperature.

48. The process according to claim 39, 41, 42, 44, 45 or 46, wherein said obtained fired honeycomb structure is further rapidly cooled from a predetermined temperature during cooling from the temperature used in said firing.

49. The process according to claim 45 or 46, wherein a temperature difference between said predetermined temperature and a temperature after said rapid cooling is not more than 900°C.

50. The process according to claim 39, 41, 42, 44, 45 or 46, wherein said obtained fired honeycomb structure is further subjected to a shock wave.

51. The process according to claim 50, wherein said shock wave is provided by ultrasound or vibration.

52. The process according to claim 39, 41, 42, 44, 45 or 46, wherein a compound of an alkali metal element or alkaline earth metal element is added to said cordierite materials.

53. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder,

forming said cordierite materials into a

honeycomb shape,

firing said honeycomb shape to form a honeycomb structure mainly comprised of a cordierite composition, and

immersing said honeycomb structure in a high temperature and high pressure water, a super critical fluid or an alkali solution.

54. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder,

forming said cordierite materials into a honeycomb shape,

firing said honeycomb shape to form a honeycomb structure mainly comprised of a cordierite composition, and

dry etching or sputter etching said honeycomb structure.

55. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure and comprising a substance having an oxygen storage capacity.

56. The ceramic support according to claim 55, wherein said ceramic support comprises CeO_2 as said substance having an oxygen storage capacity in an amount of not less than 0.01% by weight.

57. The ceramic support according to claim 55, wherein said honeycomb structure is mainly comprised of a cordierite composition.

58. A ceramic support capable of supporting a catalyst component, comprising a honeycomb structure mainly comprised of a cordierite composition, in which some of at least one of Si, Al and Mg elements constituting cordierite is replaced by Ce.

59. The ceramic support according to claim 7, 32, 35, 37 or 38, wherein a co-catalyst having an oxygen

storage capacity is supported by said ceramic support without a coating layer being formed on the surface of said ceramic support, to provide an oxygen storage capacity.

60. The ceramic support according to claim 7, 32, 35, 37 or 38, wherein a precursor to a co-catalyst having an oxygen storage capacity is provided to said ceramic support without a coating layer being formed on the surface of said ceramic support, and said ceramic support with said precursor is then heated to provide an oxygen storage capacity to said ceramic support.

61. The ceramic support according to claim 55 or 58, wherein said cordierite includes at least ones of oxygen vacancies and lattice defects in the cordierite crystal lattice.

62. The ceramic support according to claim 55 or 58, wherein said ceramic support has a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof.

63. The ceramic support according to claim 55 or 58, wherein said fine cracks have a width of not more than 100 nm.

64. A process for producing a ceramic support capable of supporting a catalyst component, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, some of said Si, Al and Mg sources being replaced by a Ce-containing compound,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder, and

firing said honeycomb shape in a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, a reducing atmosphere, an oxygen-containing atmosphere or an oxygen-free atmosphere to form a

honeycomb structure mainly comprised of a cordierite composition.

65. The process according to claim 64, wherein said obtained fired honeycomb structure is further heated to a predetermined temperature and then rapidly cooled from said predetermined temperature.

66. The process according to claim 64, wherein said obtained fired honeycomb structure is further rapidly cooled from a predetermined temperature during cooling after said firing.

67. The process according to claim 65, wherein a temperature difference between said predetermined temperature and a temperature after said rapid cooling is not more than 900°C.

68. The process according to claim 64, wherein said obtained fired honeycomb structure is further subjected to a shock wave.

69. The process according to claim 68, wherein said shock wave is provided by ultrasound or vibration.

70. The ceramic support according to claim 39, wherein a co-catalyst having an oxygen storage capacity is supported by said ceramic support without a coating layer being formed on the surface of said ceramic support, to provide an oxygen storage capacity.

71. The ceramic support according to claim 39, wherein a precursor to a co-catalyst having an oxygen storage capacity is provided to said ceramic support without a coating layer being formed on the surface of said ceramic support, and said ceramic support with said precursor then being heated to provide an oxygen storage capacity to said ceramic support.

72. A catalyst-ceramic body, comprising a catalyst component supported by said ceramic support as set forth in any one of claims 1 to 38 and 55 to 63.

73. A catalyst-ceramic body comprising a catalyst component directly supported on a ceramic support without a coating layer on the surface thereof.

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74. The catalyst-ceramic body according to claim 73, wherein said catalyst-ceramic body comprises a catalyst component in an amount as the metal element of not less than 0.01% by weight, an average distance between particles of said catalyst component on the surface of said ceramic support being in a range of 0.1 to 1000 nm.

Sub B2

75. The catalyst-ceramic body according to claim 73 or 74, wherein said average distance between particles of said crystal component is in a range of 0.1 to 100 nm.

76. The catalyst-ceramic body according to claim 73, wherein said catalyst component is at least one of metals having a catalyst activity and metal oxides having a catalyst activity.

77. The catalyst-ceramic body according to claim 76, wherein said metals having a catalyst activity are noble metals and said metal oxides having a catalyst activity are oxides containing at least one metal selected from the group of V, Nb, Ta, Cr, Mo, W, Mn, Fe, Co, Ni, Cu, Zn, Ga, Sn and Pb.

78. The catalyst-ceramic body according to claim 72, wherein said ceramic support has a multiple number of fine pores with a diameter or width of 0.1 to 100 nm on the surface thereof.

79. The catalyst-ceramic body according to any one of claims 73 to 78, wherein said ceramic support is the ceramic support as set forth in any one of claims 7 to 38 and 55 to 63.

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80. A catalyst-ceramic body comprising a ceramic support comprising a honeycomb structure mainly comprised of a cordierite composition, some of at least one of Si, Al and Mg elements constituting the cordierite being replaced by a metal having a catalyst activity.

81. The catalyst-ceramic body according to claim 80, wherein said catalyst-ceramic body contains a metal having a catalyst activity in an amount of not less than 0.01% by weight thereof.

82. The catalyst-ceramic body according to claim 80, wherein said catalyst-ceramic body contains a metal having a catalyst activity in an amount of not less than 0.01% by weight thereof and CeO_2 in an amount of not less than 0.01% by weight thereof.

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83. The catalyst-ceramic body according to claim 80, wherein said metal having a catalyst activity is at least one of noble metals, V, Nb, Ta, Cr, Mo, W, Mn, Fe, Co, Ni, Cu, Zn, Ga, Sn and Pb.

84. The catalyst-ceramic body according to claim 80, wherein said honeycomb structure has at least ones of oxygen vacancies and lattice defects in the cordierite crystal lattice, on which a catalyst component is supported.

85. The catalyst-ceramic body according to claim 80, wherein said honeycomb structure has a multiple number of fine cracks in at least one of the amorphous and the crystal phases thereof, on which a catalyst component is supported.

86. The catalyst-ceramic body according to claim 85, wherein said fine cracks have widths of not more than 100 nm.

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87. A process for producing a catalyst-ceramic body, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, some of said Si, Al and Mg sources being replaced by a noble metal-containing compound,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder, and

firing said honeycomb shape in a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, a reducing atmosphere, an oxygen-containing atmosphere or an oxygen-free atmosphere to form a catalyst-ceramic body comprising a ceramic support of a

honeycomb structure mainly comprised of a cordierite composition.

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88. A process for producing a catalyst-ceramic body, comprising the step of:

preparing cordierite materials comprising an Si source, an Al source and a Mg source as well as a binder, some of said Si, Al and Mg sources being replaced by a noble metal-containing compound and a Ce-containing compound,

forming said cordierite materials into a honeycomb shape,

heating said honeycomb shape to remove said binder, and

firing said honeycomb shape in a reduced pressure atmosphere at a pressure of not higher than 4000 Pa, a reducing atmosphere, an oxygen-containing atmosphere or an oxygen-free atmosphere to form a catalyst-ceramic body comprising a ceramic support of a honeycomb structure mainly comprised of a cordierite composition.

89. The process according to claim 87, wherein said obtained fired honeycomb structure is further heated to a predetermined temperature and then rapidly cooled from said predetermined temperature.

90. The process according to claim 87, wherein said obtained fired honeycomb structure is further rapidly cooled from a predetermined temperature during cooling from the temperature used in said firing.

91. The process according to claim 89, wherein a temperature difference between said predetermined temperature and the temperature after said rapid cooling is not more than 900°C.

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92. The process according to claim 92, wherein said obtained fired honeycomb structure is further subjected to a shock wave.

93. The process according to claim 92, wherein said shock wave is provided by ultrasound or vibration.

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94. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a catalyst component and/or a precursor of a catalyst component on said ceramic support by a CVD or PVD method.

95. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a catalyst component and/or a precursor of a catalyst component on said ceramic support by means of a super critical fluid.

96. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a catalyst component and/or a precursor of a catalyst component on said ceramic support by means of a solvent having a surface tension smaller than water.

97. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a catalyst component and/or a precursor of a catalyst component on said ceramic support by means of a solvent having a surface tension smaller than water while applying vibration or performing vacuum defoaming.

98. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a precursor of a catalyst component on said ceramic support followed by a heat treatment.

99. A process for producing the catalyst-ceramic body as set forth in claim 72, comprising depositing a catalyst component a plurality of times using the same or different compositions.

100. The ceramic support according to any one of claims 11 to 38 and 57 to 63, wherein said cordierite has a theoretical composition expressed by $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$.

101. The process for producing a ceramic support according to any one of claims 39 to 54 and 64 to 71, wherein said cordierite has a theoretical composition expressed by $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$.

102. The catalyst-ceramic body according to any one of claims 80 to 86, wherein said cordierite has a

Sub B8

theoretical composition expressed by $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$.

Sub B8

103. The process for producing a catalyst-ceramic body according to any one of claims 89 to 99, wherein said cordierite has a theoretical composition expressed by $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$.